The growth features of chub *Squalius cephalus* and comparison of five different condition indices

by

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ABSTRACT. - In this study a total of 131 chub, *Squalius cephalus* (Linnaeus, 1758) (Cyprinidae), living in Kapulukaya dam lake (Ankara, Turkey) were investigated. The growth features; age composition, age-length, age-weight and length-weight relationship and von Bertalanffy growth equations were calculated for both sexes seperately. In addition, five different condition indices that was proposed by different researchers were applied and compared.

RÉSUMÉ. - Caractéristiques de la croissance du chevaine, *Squalius cephalus* (Cyprinidae), et comparaison de cinq coefficients de condition différents.

Cette étude porte sur 131 chevaines, *Squalius cephalus* (Linnaeus, 1758) provenant du lac de barrage Kapulukaya (Ankara, Turquie). Les caractéristiques de la croissance, la composition en âge, les rapports âge-longueur, âge-poids et longueur-poids et les courbes de croissance de von Bertalanffy ont été calculés pour les deux sexes séparément. De plus cinq coefficients de condition proposés par divers chercheurs ont été appliqués et comparés.

Key words. - Cyprinidae - *Squalius cephalus* - Turkey - Condition factor - Growth.

During several decades many researchers mentioned the importance of growth features of fish species which have economical value and many statistical models were applied to fisheries biology (Ricker, 1975; Blackwell *et al*., 2000). There are many articles that have been devoted to the study of fish condition and suitability of mathematical equations for its description (Fulton, 1911; Le Cren, 1951; Jones *et al*., 1999; Richter *et al*., 2000). However, it should be noted that, unless they are tested, whether these equations fit for other species or not, remains unclear.

Chub, *Squalius cephalus* (L., 1758) is one of the most common and widely distributed cyprinid species in Europe and Anatolia. Although there are several papers dealing with the biology of chub (Prokes, 1981; Altindag, 1996; Yerli *et al*., 1999; Kalkan *et al*., 2005; Koc *et al*., 2007), this is the first study that compare different condition indices. The results obtained were compared according to Jones *et al*. (1999). In addition, it was also aimed to determine the growth features of chub such as age composition, age-length, age-weight, length-weight relationship and von Bertalanffy growth equations. The results from this study were compared to other studies from other regions of this species' range.

MATERIALS AND METHODS

In this study a total of 131 chub (*Squalius cephalus*) were investigated. Fish were captured with fyke nets and gill nets between April and November 2001 from Kapulukaya dam lake (Ankara, Turkey). The fish were brought to the laboratory and somatic weight, fork length and height at the level of dorsal fin were recorded to the nearest 0.1 g and 0.1 cm, respectively. Sex was determined by the macroscopic examination of gonads. For age determination several scales were removed from the left side, above the lateral line anterior to the dorsal fin. Scales were viewed under a microfiche reader and age of fish was estimated according to Lagler (1996).

The traditional methods were applied for the determination of length-weight relationships ($W = a \times L^b$) (Ricker, 1975). The von Bertalanffy growth equations were calculated according to the formula: $L_t = L_\infty (1 - e^{-k(t - t_0)})$. Five different condition indices; K, K', K_n, B and B' proposed by Fulton (1911), Bagenal and Tesch (1978), Le Cren (1951), Jones *et al*. (1999) and Richter *et al*. (2000), respectively, were compared. The fish condition has been traditionally estimated by the following formula developed by Fulton (1911): $K = 100 \times W/L^3$, where K = condition factor, W = body mass, L = body length

This equation assumes isometric growth, however it has been shown that fish often grow allometrically. To reduce or eliminate the effects of allometry from the estimation of fish condition, a condition factor K' has been proposed by Bagenal and Tesch (1978): $K' = 100 \times W/L^b$, where b is a constant determined from the length-weight relationship ($W = a \times L^b$).

Le Cren (1951) introduced the idea of another factor, Kn, for measuring fish condition and several authors suggested that Kn could be used to distinguish between and measure separately the influences on condition of length and other

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factors (Blackwell *et al*., 2000). This relative condition factor is calculated with the following formula: Kn = W/W', where W is the weight of the individual fish and W' is the calculated average weight for a given length, from the equation $W = a \times L^b$.

However, it is very difficult to obtain a reliable value for b, particularly if the data set used to estimate b is small or does not span a wide enough range of body lengths (Ricker, 1975; Bagenal and Tesch, 1978). To overcome or minimize these problems, Jones *et al*. (1999) proposed a new condition factor based not only on length and weight but also on height. The new factor termed B, is computed by the following equation: $B = W/(h \times L^2)$, where W = body mass, h = body height, L = body length.

However, Richter *et al*. (2000) argued about this equation and proposed a new equation which is termed B': $B' = W/(h^2 \times L)$

The results obtained from these equations were compared according to Jones *et al*. (1999). Back-calculated masses were regressed against the actual body masses and the coefficients of determination values were compared to interpret which condition factor equation gives the best results for chub, *S. cephalus*.

RESULTS

In total 131 fish specimens were investigated for the determination of the growth parameters. Fork length ranged between 10.26-33.05 cm for males and 10.56-32.30 cm for females. Total weight ranged between 13.20-610.0 g for males and 14.00-566.50 g for females. Fish aged I-VI years were present in the samples (Tab. I). It was found that the studied chub population consisted of 41.98% males and 58.02% females. Fish aged IV years were the most abundant age group followed by age group III (Tab. II). The length-weight relationship equations calculated for both sexes are shown in table III. The value b was found to be higher than 3, in both sexes. The von Bertalanffy growth equations are given in table IV. L_∞ values for males (45.98 cm) were higher than for females (40.55 cm).

The average condition factors were found as follows; K = 1.54, K' = 1.26, Kn = 1.01, B = 6.55 and B' = 28.59. The changes in the condition factor was only expressed with K, because only K was calculated in other studies concerning *S. cephalus* which makes impossible to compare K', Kn, B and B' to other studies. The average K value in April was 1.62 and it was 1.53 in November. The average condition factors were used to back-calculate the body mass of fish. The results of regression analysis between the actual and back-calculated body masses are shown in table V. As it is shown in the table, the highest coefficient of determination was found for B and the lowest for K.

Table I. - Length and weight of *Squalius cephalus* at different age classes. *[Tailles et poids pour les différentes classes d'âge.]*

Age	Length (cm)			Weight (g)		
	Male	Female	M+F	Male	Female	M+F
I	10.26	10.56	10.37	13.20	14.00	13.50
II	15.80	16.81	16.41	54.75	66.50	61.80
III	23.05	23.07	23.06	217.83	212.18	214.52
IV	26.99	27.38	27.25	348.42	353.61	351.88
V	29.56	29.61	29.58	445.00	456.25	449.74
VI	33.05	32.30	32.67	610.00	566.25	588.13

Table II. - Frequency distribution of *Squalius cephalus* at different age classes. *[Distribution de fréquence pour les différentes classes d'âge.]*

Age	Male		Female		M+F	
	N	%	N	%	N	%
I	5	3.82	3	2.29	8	6.11
II	4	3.05	6	4.58	10	7.64
III	12	9.16	17	12.97	29	22.13
IV	19	14.50	38	29.01	57	43.51
V	11	8.39	8	6.11	19	14.50
VI	4	3.05	4	3.05	8	6.11
Total	55	41.98	76	58.02	131	100.00

Table III. - Length-weight relationships of both sexes of *Squalius cephalus*. *[Relations taille-poids pour les deux sexes.]*

Sex	Length-weight relationship	Correlation (r^2)
Male	$W = 0.0054 \times L^{3.3497}$ $\mathrm{Log}W = -2.2676 + 3.3497\ \mathrm{Log}L$	0.987
Female	$W = 0.0057 \times L^{3.3339}$ $\mathrm{Log}W = -2.2441 + 3.3339\ \mathrm{Log}L$	0.978
M+F	$W = 0.0055 \times L^{3.3417}$ $\mathrm{Log}W = -2.259 + 3.3417\ \mathrm{Log}L$	0.981

Table IV. - Results of the regression analysis between the actual body mass and the back-calculated body mass from the average condition factors. *[Résultats de l'analyse de régression entre la masse actuelle du corps et la valeur rétrocalculée à partir des facteurs de condition moyens.]*

	Growth parameters			Growth equations
Sex	L_∞	k	t_0	$L_t = L_\infty (1 - e^{-k\,(t-t0)})$
Male	45.98	0.2026	-0.2446	$L_t = 45.98\,(1 - e^{-0,2026\,(t + 0.2446)})$
Female	40.55	0.2587	-0.1774	$L_t = 40.55\,(1 - e^{-0.2587\,(t + 0.1774)})$
M+F	42.64	0.2348	-0.1918	$L_t = 42.64\,(1 - e^{-0.2348\,(t + 0.1918)})$

Table V. - Regression analysis between the actual and back-calculated indices. *[Analyse de régression entre les indices actuels et rétrocalculés.]*

Condition indices	K	K'	K_n	B	B'
Coefficient of determination	0.938	0.954	0.948	0.966	0.956
Regression slope (d)	0.930	0.937	0.973	0.955	0.985
SE_d	0.017	0.021	0.021	0.015	0.018

DISCUSSION

Chub, *Squalius cephalus* (L., 1758) is one of the most common and widely distributed cyprinid species in Europe and Anatolia. Although there are several papers on the biology of this economically important fish species both from Turkey (Ekmekci, 1996; Altindag, 1996; Yerli *et al.*, 1999; Koc *et al.*, 2007) and Europe (Prokes, 1981), little is known on the growth of this species in Turkish reservoirs such as Kapulukaya dam Lake.

The weight-length relationship equations calculated for male and female chub clearly indicates that the growth of chub in Kapulukaya dam lake is allometric. Similar findings were also reported by Prokes (1981) and Altindag (1996). However, the value b in other studies range between 2.49 and 3.53 (see Koc *et al.,* 2007) which might rise from the ecological differences between the study areas and it is known that different stocks or populations display different levels of condition according to the characteristics of their habitats (Perry *et al.*, 1996). In the present study, the von Bertalanffy growth equations shows that the L_∞ value calculated for males is higher than for females: our findings are in agreement with those of Altindag (1996) and Kalkan *et al.* (2005) and in disagreement with Koc *et al.* (2007).

In the present study, Fulton's condition factor (K) for chub was found equal to 1.54 that is similar to K values for chub from other studies: 1.60 in Sariyer dam lake (Ekmekci, 1996), 1.57 in Aksehir Lake (Altindag, 1996), 1.47 in Karakaya dam lake and 1.67 in Ikizcetepeler dam lake (Koc *et al.*, 2007).

The analysis of fish condition data has become a standard practice in the management of fish populations as a measure to interprete their physiological state and fish with a low condition factor presumably have been exposed to an adverse physiological environment or insufficient nutrition (Blackwell *et al.*, 2000). Fulton's condition factor K is the most commonly used index in fisheries biology. However, for fish which exhibits allometric growth, K' looks better. It seems that Kn could be used to emphasize the influences of other environmental factors (Blackwell *et al.*, 2000). However, in the calculation of Kn, a time consuming parameter "b" needs to be estimated. Jones *et al.* (1999) stated that their equation B, is a better indicator and is more sensitive to the physical state of fish and easier to calculate. However, according to Richter *et al.* (2000), B' gives better results. In this study we found that B gave the best fit in the regression analysis (Tab. IV), with an highest coefficient of determination. On the other hand, condition factor K gave the least fit in the analysis. So, we suggest to use B when the height of the fish is available, otherwise K' would give satisfactory results.

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